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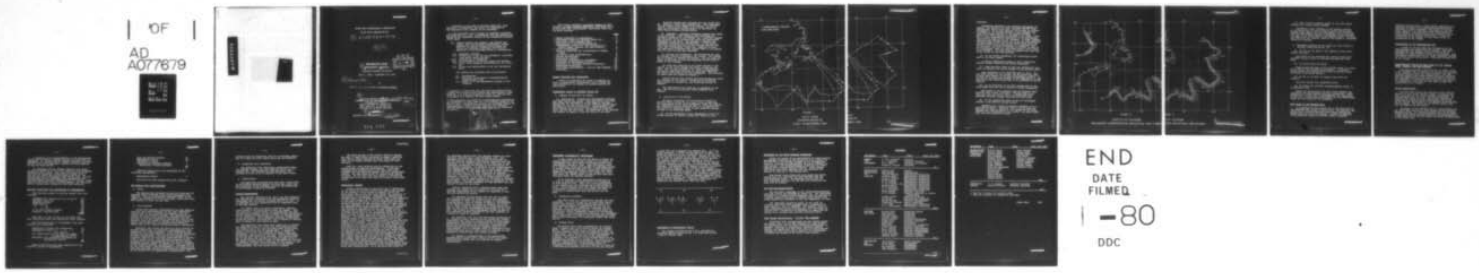

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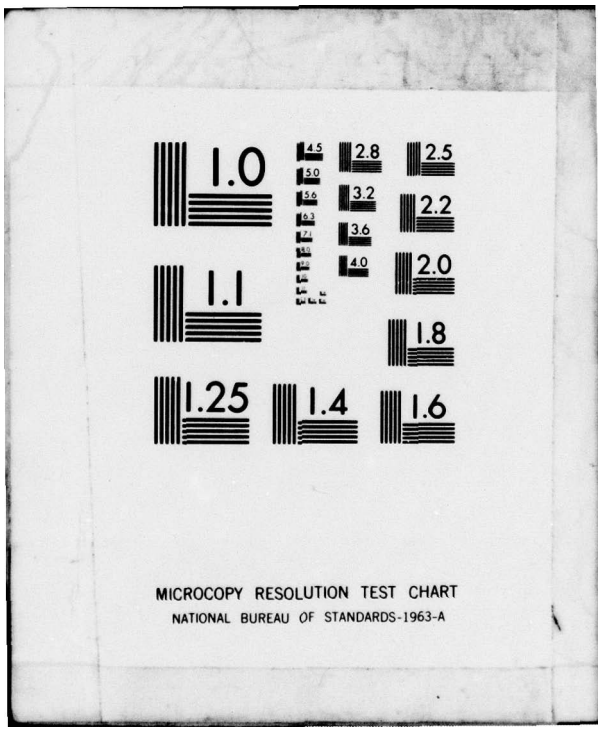
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Name

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

(14) WHOI-REF-49-46

(12) 22

(6) Reference No. 49-46

OCEANOGRAPHIC RESEARCH.

conducted during the period

July 1, 1949 - September 30, 1949

(15) N6onr-277

(9) Periodic Status Report No. 13, 1 Jul-30 Sep 49.

Submitted to the Oceanographic Division
Hydrographic Office
Under Contract No. N60nr-277
Task Order No. 1, NR-083-004
With Office of Naval Research

(11) Oct 49

APPROVED FOR DISTRIBUTION C.O'D. Iselin
Director

381 000

slt

According to the terms of Contract N6onr-277, Task Order No. 1, NR-083-004, the work to be performed by the Contractor shall consist of the following:

1. The Contractor shall furnish the necessary personnel and facilities for, and, in accordance with any instructions issued by the Scientific Officer or his authorized representative shall

(a) conduct surveys and research, and analyze and compile data and technical information, prepare material for charts, manuals and reports, and foster the training of military and civilian personnel in the following fields of oceanography:

(i) permanent currents;
(ii) interaction of the sea and atmosphere, including wind waves, swell and surf;
(iii) distribution of organisms;
(iv) characteristics of the sea bottom and beaches;
(v) tides, tidal currents and destructive sea waves; and
(vi) physics and distribution of sea and terrigenous ice*;

and perform the following work in particular:

(1) (Confidential)
(2) collection of analyses of bathythermograph observations**; and
(3) conduct of a wave measurement program in the Atlantic.

* Research in connection with the relations between North Atlantic sea-ice and Arctic weather was transferred to Task Order No. 5 of Contract N6onr-277 on May 15, 1949 and will be reported in a separate Periodic Status Report.

** The tabulation and filing of bathythermograph observations was transferred to Task Order No. 6 of Contract N6onr-277 on May 15, 1949. Observations received and processed during the third quarter of 1949 have been reported in a separate Periodic Status Report covering Task Order No. 6 (Reference No. 49-45).

ABSTRACT

This report contains a quarterly summary of work carried out ~~under Contract Nonr-277, Task Order No. 1~~ by the Woods Hole Oceanographic Institution under the following headings:

ABSTRACT

Papers submitted for publication

"Notes on determining the depth of sampling in serial oceanographic observations" by Mr. Pollak has been submitted to the Journal of Marine Research for publication.

Preliminary report on ATLANTIS Cruise 157

1. Summary of work done on Cruise.

(a) Hydrography. Seventy-four hydrographic stations were made during the cruise. Some difficulty with large wire angles was encountered at the edges of the Gulf Stream, but all but three of these stations reached below the depth of the main thermocline. Approximately 1,500 water samples were taken for the analysis of salinity which has not yet been made. The positions of the stations are plotted in Figure 1, with the track of the ship.

Fourteen records were obtained with the 10,000 foot BT. Eleven of these were satisfactory. This instrument is very useful on the edges of the Stream. It can be used as a substitute station when it is difficult to lower Nansen bottles satisfactorily.

(b) Chemistry. Inorganic Phosphate samples were taken at all stations. Other chemical data were taken on alternate crossings of the Stream; e.g., dissolved Oxygens and Silicates on one crossing and total and particulate Phosphates on the next. The analyses of Oxygens and inorganic Phosphates was satisfactory. At the outset, some difficulties were met in the Silicate analyses but these were subsequently ironed out. Samples of total and particulate Phosphate were brought back to the laboratory but have not yet been analyzed.

(c) Geology and Geophysics. The Fathometer was kept in constant operation throughout the cruise. The records are at present at Columbia University. One sea mount was found in Latitude 47°-45'N and Longitude 41°30'W with a depth of 1320 fathoms.

No cores were obtained on the first section of the cruise; on the third attempt the entire coring rig was lost. The rig was replaced at St. John's, Newfoundland, and during subsequent sections 12 cores were obtained. The Ewing coring device was used throughout. The positions of these cores are marked on Figure 1.

Bottom reflectivity studies were made during the first two sections of the cruise. During the last section, Sofar bombs were dropped for the receiving station in Bermuda.

The Magnetometer was towed for an aggregate of one day. Its use was discontinued after repeated cable failure.

2. Objectives of the Cruise.

The major objectives of the cruise are listed in Periodic Status Report No. 12, July, 1949, in the form of a memorandum to the Chief Scientist. While the results are incomplete without salinity data, it is possible on the basis of temperature alone to give tentative answers to some of the questions posed.

(a) Is the meandering a local phenomenon or does the Stream continue to follow a snake-like course in mid-

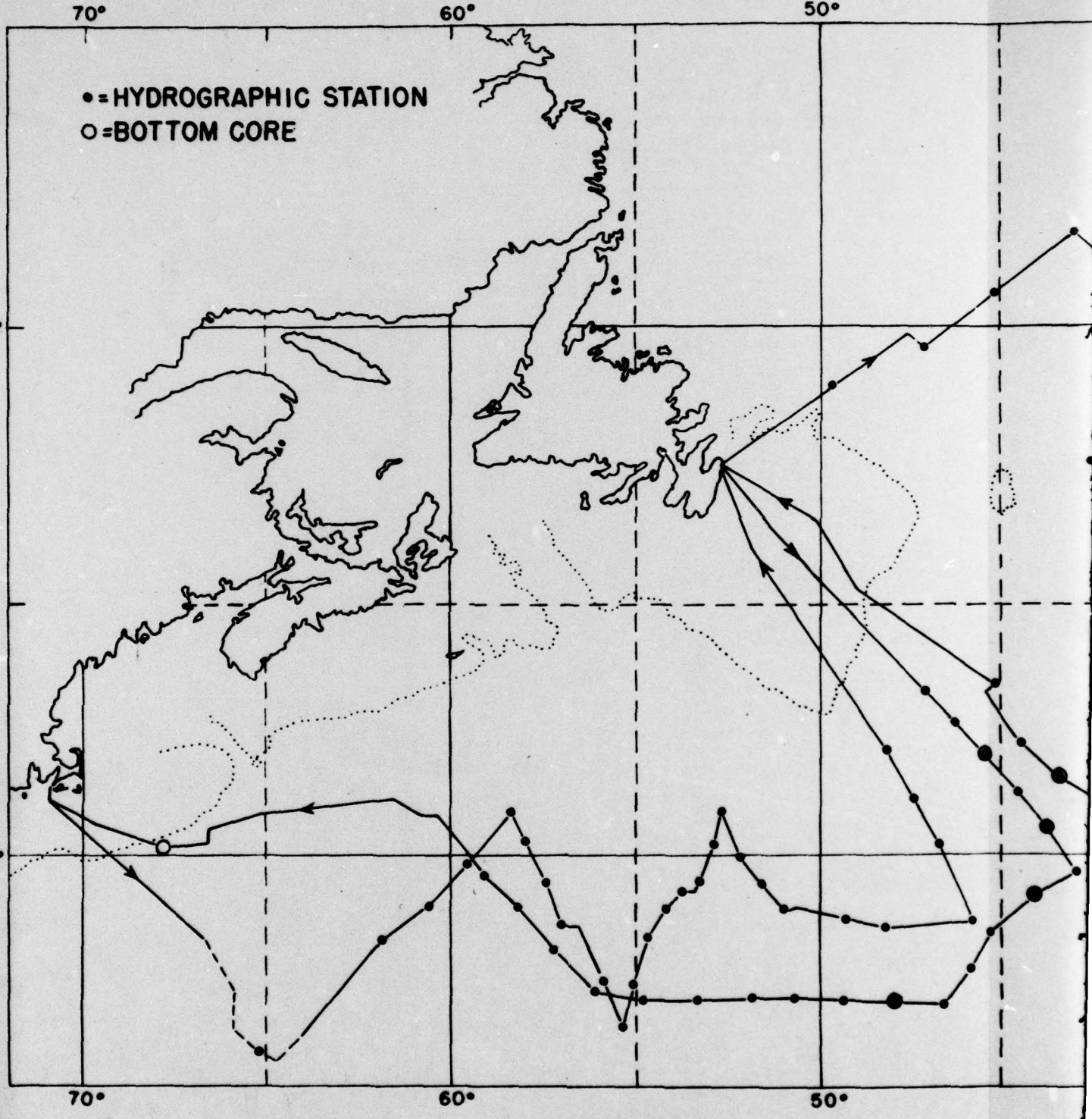
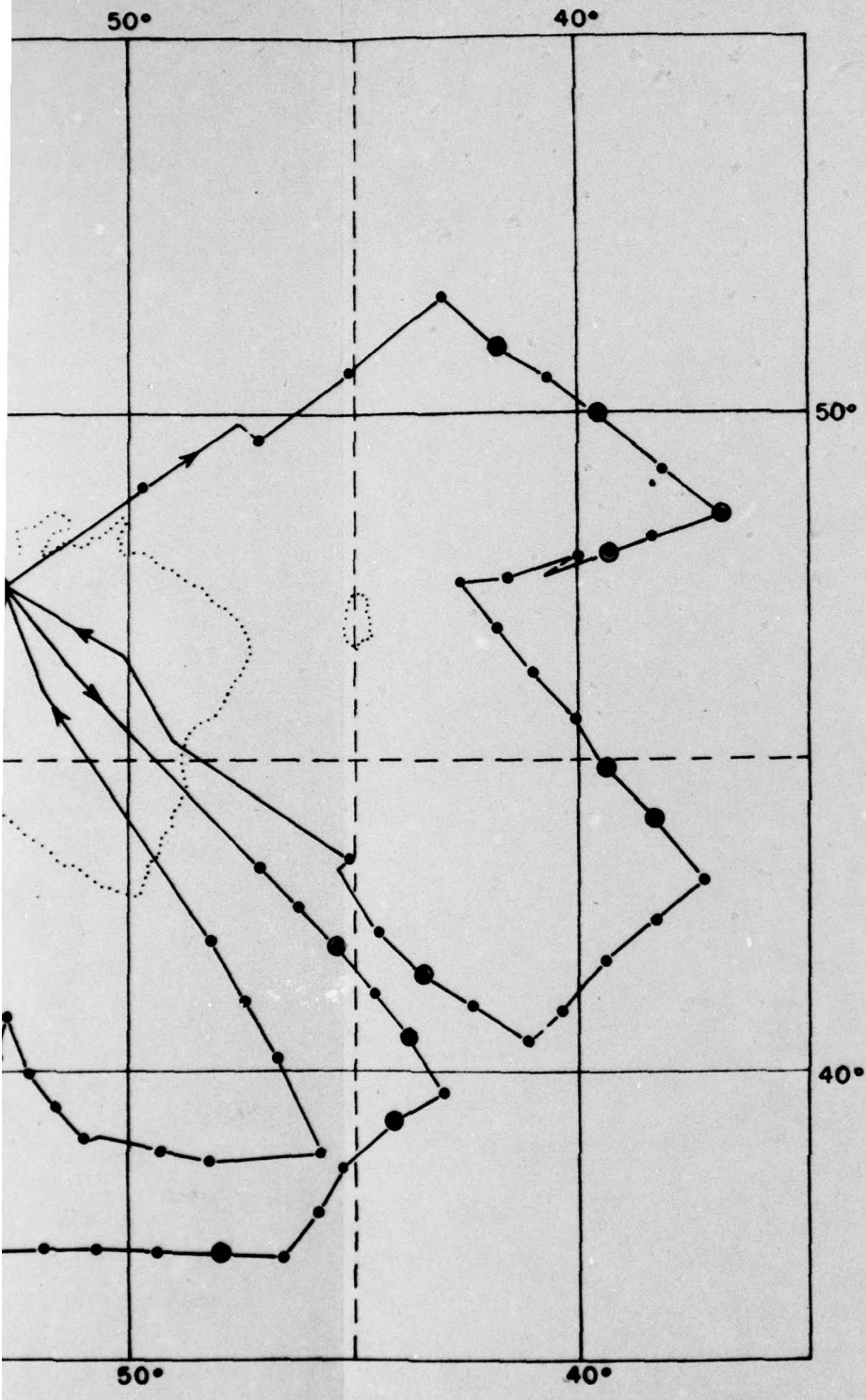


FIGURE 1

SHIP'S TRACK
ATLANTIS CRUISE 157
6 JULY - 12 SEPTEMBER, 1949.



ACK
ISE 157
BER, 1949.

Atlantic?

Meandering appeared to be prevalent throughout the cruise. The depth of the 10°C. isotherm derived from hydrographic and BT data taken on this cruise is plotted in Figure 2. In the main portion of the diagram, the first and second sections of the cruise are used. A part of the third section is included in an inset. Overall it shows considerable similarity to the preliminary chart of the depth of the 10° isotherm. It does, however, establish that meanders exist as far as the 40th meridian, and are marked at the tail of the Grand Banks where the contours curve from southeasterly to a northerly flow. To the north, the flow of contours is similar to that of the preliminary chart but variations from it seem likely to be meanders. Previous study of meanders has been confined to west of the 60th meridian.

(b) Is the bottom topography the controlling factor east of the Grand Banks?

A cursory examination shows no clear correlation between current direction and bottom topography.

(c) Does the steep slope of the main thermocline continue to underlie the abrupt changes in the surface layer?

Work completed so far indicates that it does. For the first section of the cruise, the BT profile has been plotted superimposed on the deep hydrographic profile. In no case do any important changes in the temperature of the deep water take place which fail to be reflected in the BT profile.

(d) Is the branching of the Gulf Stream east of the Grand Banks real and is it related to bottom topography?

The answer to this question must be deferred until salinity data become available. Thermal data do not show any clear cut split, but it is understood that important salinity changes take place in this area.

(e) Is the preliminary chart of the 10° isothermal surface a good surface current chart?

Considered as a chart of average conditions it is a good current chart. Variation from it in the shape of meanders is shown in Figure 2. No changes in the basic pattern were encountered in this cruise. No ship's drift data have been compared to date.

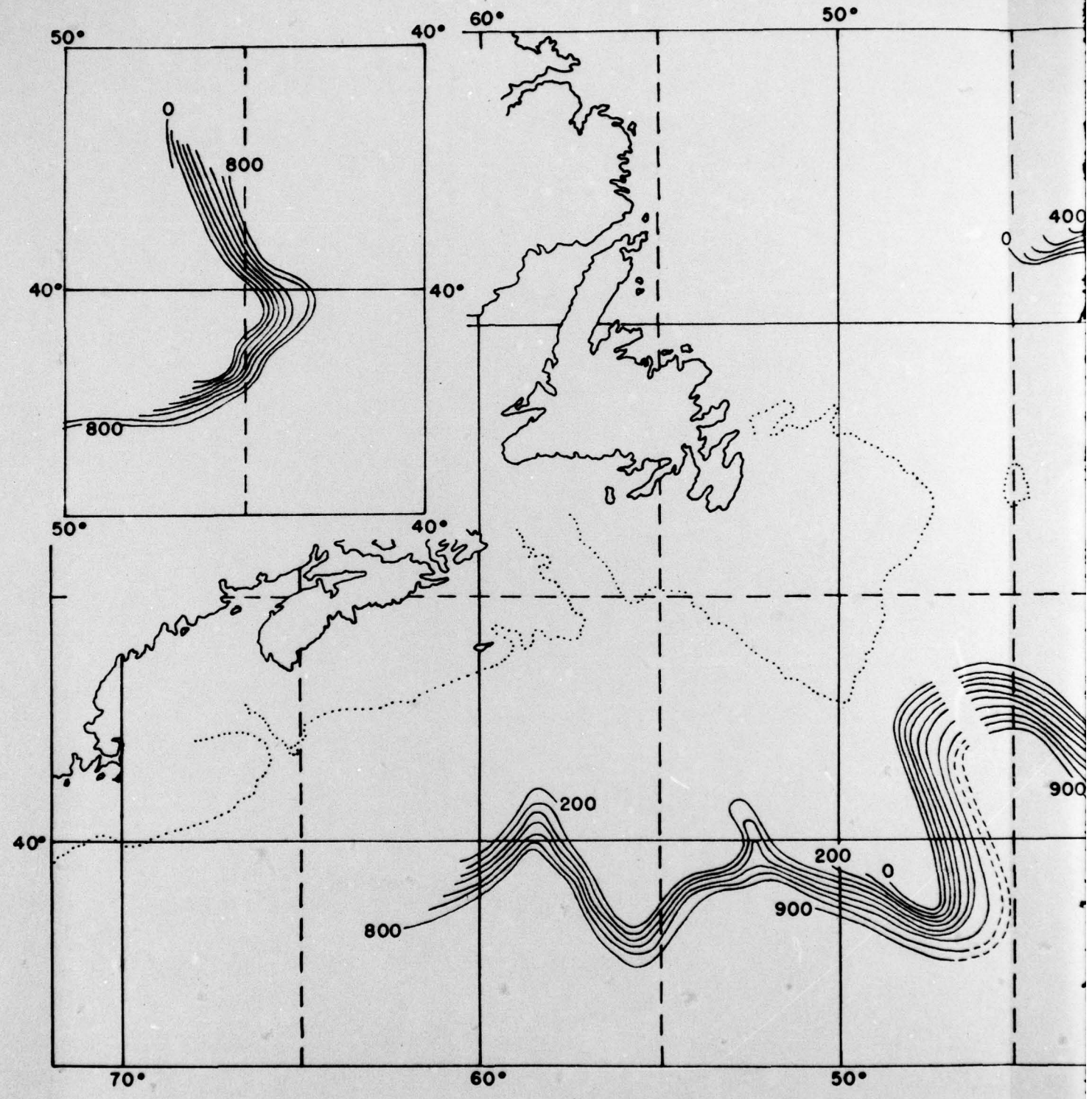
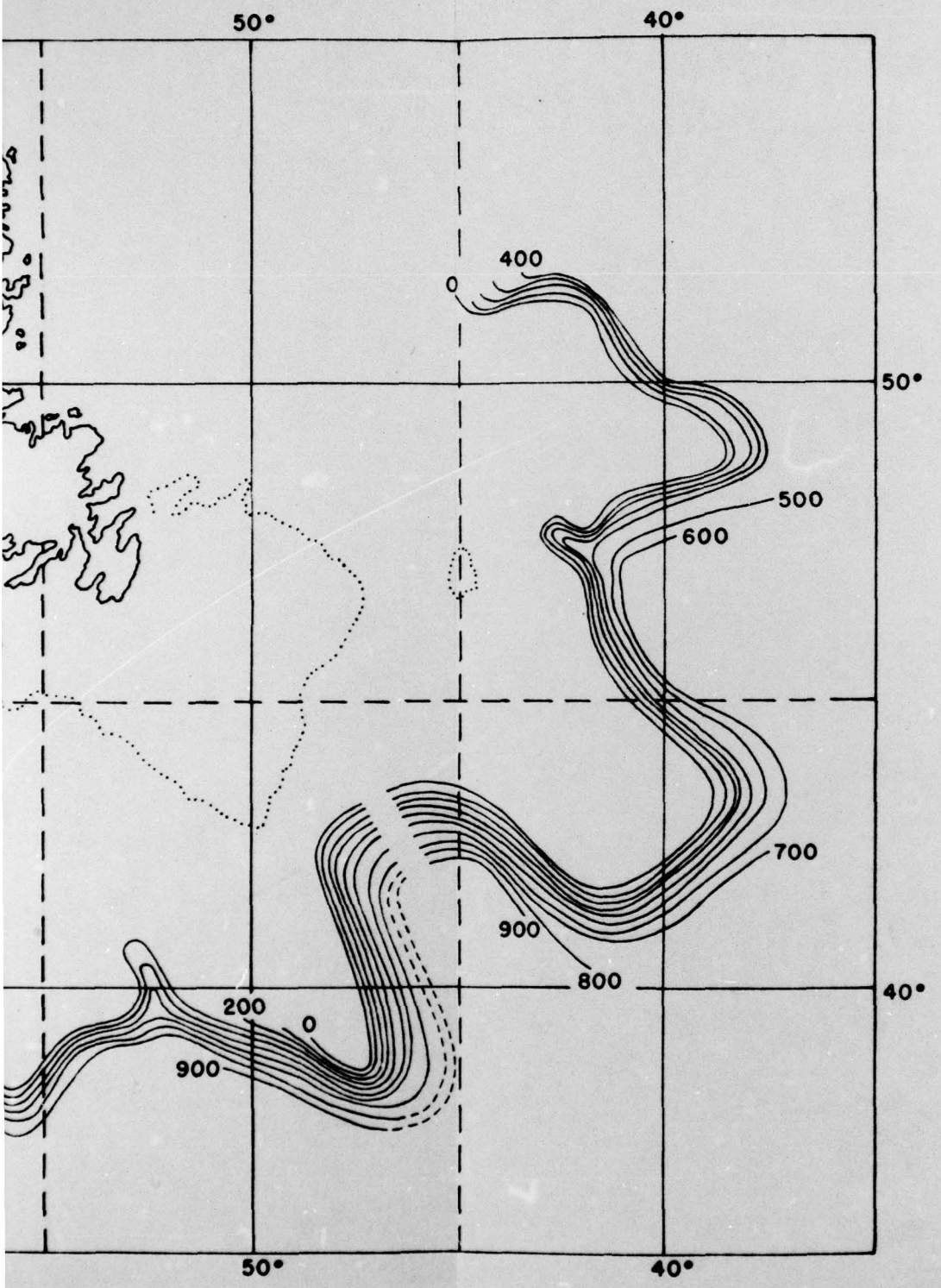


FIGURE 2

DEPTH OF 10° ISOTHERM

PRELIMINARY INTERPRETATION, NEGLECTING TIME ELEMEN



GURE 2

F 10° ISOTHERM

TION, NEGLECTING TIME ELEMENT.

(f) Does the most northern branch of the Gulf Stream continue as a swift narrow current?

Apparently; Loran coverage in the northern section of the cruise was not good enough to afford any accurate current measurements, but the hydrographic and BT profiles show the same abrupt descent of isotherms as characterizes the edge of the Stream off the New England coast. Probably the velocities are somewhat lower as the number of isotherms involved is smaller.

3. Secondary purposes of the cruise are also listed in Periodic Status Report No. 12.

(a) To fill in the gaps in the network of deep hydrographic stations.

Two-thirds of the stations made on this cruise fall in degree squares where no previous stations have been made.

(b) To provide data for Sofar.

Eighty-eight per cent of the stations reach to a depth below that of the minimum sound velocity. In general, Nansen bottles were spaced at 200 meter intervals around the depth of the Sofar channel.

(c) To add to the score of chemical data from the Atlantic.

This has already been summarized above.

(d) To extend the detailed bathythermograph survey to an important area.

Hourly BT observations were made while underway and continuous temperature/depth profiles constructed. These profiles are a great aid in understanding the hydrography of the area, particularly since nearly all the observations reach the full range of the instrument.

Deep water in the Brownson Deep

An investigation was carried out of the deep water in the Brownson Deep, north of Puerto Rico. The vertical temperature and salinity structure show almost homogeneous water below the rim of the trench. Although an analysis of the potential density structure showed a slightly

unstable stratification, a more precise computation of stability by means of the Hesselberg-Sverdrup method indicated a stable structure. The source of the deep water appears to be Antarctic Bottom Water from the South Atlantic, modified during its northward flow by mixing with North Atlantic Deep Water. A paper for publication on the results of this study is now in preparation by Mr. Pollak.

Oceanography of the Mediterranean Sea

A study of the structure and circulation of the Mediterranean and Aegean Seas was started. The water exchange with the Atlantic Ocean via the Strait of Gibraltar is being studied as part of the problem. Some preliminary computations of the volume transport through the Strait proved inconclusive. This work is being done by Mr. Pollak.

Oceanographic surveys off East Coast of U.S. between Miami, Florida, and Cape Hatteras

The data collected in May and June by CARYN, Cruise 7 and ALBATROSS III, Cruises 18, 19, 21 and 22, mentioned in the previous report, are being studied. The temperature profiles for these cruises have been completed. Only the CARYN salinity data have been drawn in section, the ALBATROSS III salinities still being in the hands of the analysists. The study of this data is under the supervision of Mr. Bumpus.

Arctic oceanography

In late June, orders came through for Mr. William Butcher to go to Point Barrow, Alaska, to continue the work being done at the Arctic Research Laboratory. He arrived there early in July. His worked consisted of assisting Mr. Bates from the Hydrographic Office and making various observations of the geology of the beaches in the region. The report of his and Mr. Bates' work will be drawn up by the latter.

In August, it was decided that Mr. Lloyd Hoadley and Mr. David Owen would go to Point Barrow for the October-November period. Mr. Hoadley finished work on the light-weight Arctic winch and also worked on the development of a time-lapse motion picture camera for aerial reconnaissance of the Arctic ice.

A conference with representatives of the Hydrographic Office and the Office of Naval Research was held early in September. Mr. Hoadley and Mr. Metcalf attended from WHOI. Shortly after this conference, Hoadley and Owen departed by air for Point Barrow.

Mr. Martineau and Mr. Hichens departed from Boston on the USS EDISTO on 15 July for a cruise in the Greenland-Canadian Arctic region. They spent the latter half of June and the first half of July being briefed by Mr. Metcalf and getting equipment ready for the trip. The two men returned early in September with temperature data, salinity damples and many photographs of the region. These data will be worked up in a routine manner. Mr. Martineau and Mr. Hichens have returned to New York University.

Salinity titrations and calibrations of thermometers

The following groups of salinity samples have been titrated:

ALBATROSS III, Cruises 18, 19, 21 and 22	247
ATLANTIS Cruise 154	245
Barnstable Harbor	147
CARYN Cruise 7	580
" " 11	10
" " 12	521
U. S. Public Health Service	171
ASTERIAS - Raritan River	400
	2,321

This work has been carried out by three full-time technicians under the supervision of Mr. Penrose.

The following groups of thermometers have been received for calibration:

University of Miami (for calibration)	12
Hydrographic Office (" ")	12
" " (for repair)	24
U.S. Coast Guard (for 0° check and return to Hydrographic Office)	6
USS MAURY (for calibration and return to Hydrographic Office)	6
	60

Index calibrations have been completed for the following groups of thermometers:

Fish and Wildlife Service	18
Hydrographic Office	16
University of Miami	6
Institute of Fisheries Research (University of North Carolina)	2
	42

Pressure factors have been determined on the following thermometers:

Hydrographic Office	9

This work has been carried out by Mr. Penrose.

Sea surface wave investigations

1. Field

Wave gauges were installed at Cape Cod locations off Highland Light and Nauset Light about one-quarter mile offshore. Daily recordings were initiated early in the summer and continued for about six weeks, after which they were reduced to about one per week.

2. Data analysis

During this quarter, investigation has been primarily concerned with characteristics of the auto correlation function and of the resulting correlograms, both for natural data and synthetic models. The statistical properties of natural time series which underlie the computation of the auto correlation coefficient, such as the variance, mean and length of series, are being studied in detail, and results are now available which serve to define some of the factors limiting practical computation.

Synthetic time series are set up so as to consist of various combinations of controlled trigonometrics, autoregressive and random functions. Their statistical properties are then investigated in relation to the properties of their correlograms. The results are throwing considerable light on the practical interpretation of correlograms of natural data. One important practical result brought out by the investigation is that the sea surface roughness pattern appears to consist sometimes of seaswell of two different periods and amplitudes. Although this is not the usual rule, a few correlograms of sea surface wave data from the North Atlantic have properties characteristic of the presence of two independent trigonometrics. The

periods cannot be identified from the correlogram itself, and it is only the lower period which may be estimated.

3. Mechanical auto correlator

The mechanical auto correlator, constructed during the previous quarter, has been improved and is now in constant use. The machine has been described, publication of which is to be expected in the near future.

4. Publications

One manuscript resulting from this work, "Principles of Time Series Analysis Applied to Ocean Wave Data", has been published in the September issue of the Proceedings of the National Academy of Sciences.

Current measurements

Mr. von Arx, assisted by Mr. Hall, has been preparing for publication a description of the geomagnetic electrokinetograph and the results achieved with it to date. It is expected that this manuscript will be completed early in the next quarter.

Dr. Edmond Watson of Queen's University, Ontario, again worked at the Institution during the summer. With the help of Mr. Robert Plante, he reconditioned his deep current meter designed and built before the war specifically for the problem of determining the layer of minimum motion in the open ocean. This instrument provides a continuous record of velocity and direction, and is capable of working down to depths of 1,000 meters or more.

The experiment undertaken this summer was as follows. The CARYN was allowed to drift with the surface current for several days in an area centering about thirty miles south of the outer edge of Georges Bank. A detailed record of her drift, as determined by Loran fixes, was maintained. During much of the time, surface velocities as high as three knots were observed. The current meter was at the same time operated at various depths down to the oxygen minimum layer in order to determine (a) the rate of change of velocity with depth and (b) the motion of the oxygen minimum layer, where, according to the German oceanographers, the flow should be at a minimum.

One short section of the record, which Dr. Watson was able to study before returning to Canada, indicated that with a surface velocity of about three knots the water at the oxygen minimum layer was moving at about one knot.

This is a very critical type of observation at the present stage of physical oceanography. It has been attempted here several times in the past, both from anchored and from drifting vessels, but with inconclusive results. The new factor which Dr. Watson could exploit is Loran. He will have time this winter to analyze his results and it is hoped that they will yield a convincing result.

Theoretical studies

Recent observations of velocities and of temperature in the region of the Gulf Stream have shown large changes of the position of the current in general and of the sharp shear zone on the left side (facing the direction of the current) in particular. Furthermore, observational evidence shows the frequent existence, east of Cape Hatteras, of wave-like patterns of the shear zone with wave length of the order of 250 miles. No such formations have been observed southwest of Cape Hatteras where the shear zone is in close proximity to the continental shelf. Drs. Panofsky and Haurwitz of New York University investigated whether this so-called "meandering" of the Gulf Stream can be explained by instability of the current system so that it is stable while close to the continental shelf, but unstable when it moves farther away from the shelf north of Cape Hatteras. The models which were considered consisted of vertical slabs of fluid extending without limit in the current direction and having a finite width in the direction normal to the current. The current flow was assumed to be constant in the slabs representing the waters outside the Gulf Stream and linearly increasing and decreasing, respectively, in the direction normal to the flow throughout the two interior slabs representing the Gulf Stream waters. In agreement with the actual observations the zone in which the current velocity increases has been assumed to be much more narrow than the zone in which the current decreases. The current velocity was assumed to be continuous, and only the current shear shows discontinuous changes. The density of the water was considered as uniform, so that only the effects of the shear and distance from the continental slope on the stability and instability of the current system were taken into consideration. It is believed that these are

the important factors while any possible effects of gravitational stability play a very secondary role. The influence of the earth's rotation has been allowed for, but the Coriolis parameter was assumed constant since the curvature of the current profile is so large that it must completely overshadow any effects of the variability of the Coriolis parameter. In addition to the 4-layer system some simpler systems with only two or three layers were also considered. It was found that under certain conditions this current model of the Gulf Stream can be unstable, that is, waves similar to those observed can develop spontaneously. However, if the zone of strong current shear is very close to the rigid boundary of the model no unstable waves exist. This result suggests why no meandering of the Gulf Stream is observed southwest of Cape Hatteras where the current is close to the shore.

Both Dr. Haurwitz and Dr. Panofsky spent some time studying the results and the merits of the Ocean Wave Analyzer constructed by Mr. Klebba and comparing it with the auto-correlation method.

Dr. Panofsky studied mainly with the aid of actual wave records how much the results of the Wave Analyzer are modified if there are slight changes in instrumental characteristics, such as changes in speed or circumference of the wheel on which the record is mounted, and if one and the same record is analyzed with a slight addition of data at one end and corresponding subtraction at the other end. The results of these experiments showed changes in the frequency diagrams produced by the Wave Analyzer, of a nature as might be expected.

Dr. Haurwitz, with the very substantial assistance of Dr. Seiwell's group, analyzed various artificial records constructed from tables at random numbers and from simple mathematical functions which indicated that considerable doubts may appropriately be entertained concerning the interpretation of the frequency diagrams given by the Wave Analyzer until an ordinate scale is definitely established and until more is known about the response of this analyzer to records with very similar periods.

Dr. Charney, a mathematician at the Institutefor Advanced Study, spent about a month at WHOI this summer familiarizing himself with the problems of dynamic oceanography.

Unattended oceanographic instruments

In the course of work for the Bureau of Ships, Mr. Arthur Klebba had given some thought to the design of instruments that could obtain continuous records over considerable periods of time. Some preliminary tests of a "hydraulic clock" gave promise of obtaining records of several years duration with only a small electrical power drain. Since continuous records are very badly needed in oceanography, early in the summer on a part-time basis, Mr. Klebba began to take up this work more seriously under the present contract.

To be effective, such instruments would have to be used in quantity and inevitably a fair percentage of them would be lost. Thus, the first consideration is how cheaply can the recording and timing system be built. Two instruments have been under consideration: a temperature recorder that can operate for three years and a current meter that can operate for one year.

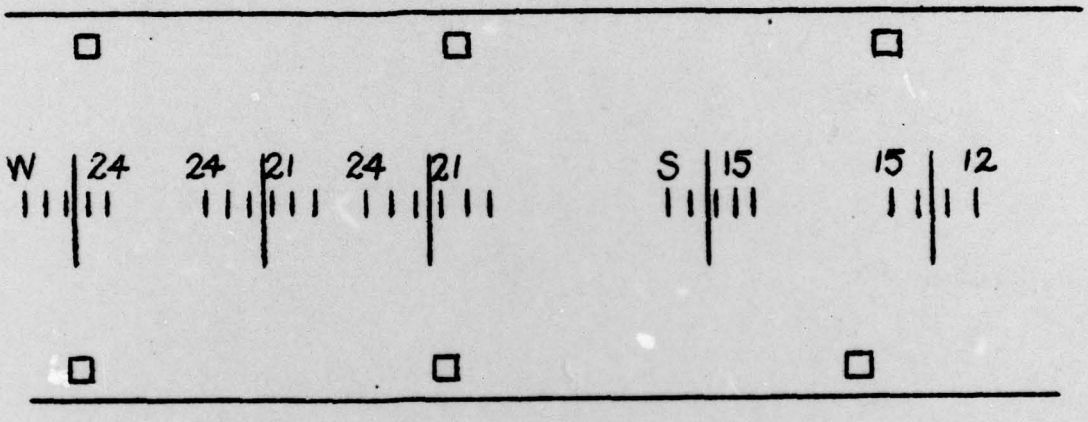
1. Temperature recorder

The first model of a temperature recorder has been completed. It is to be used by the Woods Hole Oceanographic Institution's Marine Meteorology group for a three month recording of temperature off the tip of Cape Cod. The cost of commercial components and raw materials is approximately $43.00. A second model incorporating certain fundamental changes is now nearing completion. After drawings have been made, the instrument can be duplicated in quantity with interchangeable parts. Under these conditions, the instrument should cost about $80.00.

2. Current meter

The present plan under consideration is to photograph a compass dial on 16 mm film inside the current meter. This is believed to be a fairly simple matter, the only elements needed being the compass, a lens, and a tape drive. The film is to be driven continuously by a clock work similar to the one in the temperature recorder. The "propeller" of the current meter can be magnetically coupled to the inside of the case as in the Roberts' current meter and can drive a worm reduction. Upon the completion of a predetermined number of "propeller" revolutions, a set of contacts can close for a predetermined exposure time which in turn can actuate

a light bulb and illuminate the compass dial. If it is found necessary, a simple shutter may also be used. It should be possible to use a standard roll of 100 feet of 16 mm film for a period of one year. Reading of the film can be done in standard editing devices for 16 mm film. The compass reading is always oriented so that the observer can read it directly. The speed of the current would be inversely proportional to the distances between readings. Photographing the compass will make the instrument much less complex. Most current meters require massive compass magnets. In each case, the compass device is a special one which requires a great deal of balancing. In addition, it must be handled very carefully because of its mass and suspension. The arrangement described above can be handled without any regard for suspended or pivoted masses in the instrument. A typical record which the instrument can produce would look like this:



Assistance to Hydrographic Office

Mr. Bumpus accompanied the U.S.S. SAN PABLO as Technical Advisor during Cruise 3 of Task Unit 49.415, a part of Project AMOS.

Assistance to the Naval Research Laboratory

During the course of an investigation of sound velocity measurements conducted by NRL aboard the U.S.S. MALOY and the PCE 849 in the Bermuda triangle of the northwestern Atlantic, correlating oceanographic data were obtained on each station. 181 bathythermograph slides and 145 water samples were obtained while on station. Water samples and slides were taken underway with the auxiliary sea sampler in addition to the station data.

Half-hourly Loran fixes were made aboard the MALOY. During each fix a position was also obtained from the Dead Reckoning Tracer. By comparing the fix with the dead reckoning position, the set and drift affecting the ship will be plotted.

The Bathythermochronograph

Two successful lowerings of the bathythermochronograph were made aboard the ATLANTIS on Cruise 157. The instrument consists of a standard bathythermograph with the addition of a timing element containing a circular smoked glass slide which records both pressure vs time and temperature vs time.

The instrument should be useful in the study of internal waves and other phenomena when a comparatively short period of time is involved. For example, three of these instruments placed strategically on a wire could be lowered into a thermocline to determine the amplitude and period of an internal wave possibly occurring there.

Gulf Stream investigation - H.M.C.S. NEW LISKEARD

Subsurface data obtained with the sea sampler during the cruise (NL16) of the NEW LISKEARD have been studied in collaboration with the Naval Research Establishment in Halifax. Sections of temperature, salinity, sigma-t, density and oxygen have been drawn and are being analyzed. Analysis is also being done by means of T-S correlation to define the sources of the water (0-100 meters).

PERSONNEL

ASSIGNMENT	NAME	TITLE	TOTAL MAN DAYS*
GENERAL TASK ASSIGNMENT	C. O'D. Iselin**	Director	
	A. C. Redfield	Associate Director	
	F. C. Ryder	Assistant to Director	
	Jeanne M. Backus	Secretary	
			49
HYDROGRAPHIC OBSERVATIONS AND ANALYSES	Robert Abel	Chemist	
	Dean Bumpus	Oceanographer	
	William Butcher	Hydrographic Technician	
	Arnold Clarke	Hydrographic Technician	
	R. H. S. French	Hydrographic Technician	
	Carlyle Hayes	Hydrographic Technician	
	E. R. Hichens	Hydrographic Technician	
	C. O'D. Iselin, Jr.	Hydrographic Technician	
	Eugene Krance	Hydrographic Technician	
	P. C. Malicoat	Hydrographic Technician	
	D. P. Martineau	Hydrographic Technician	
	Frank Mather	Research Associate	
	W. G. Metcalf	Research Associate in Arctic Oceanography	
	Arthur Miller	Research Associate	
	R. Plante	Hydrographic Technician	
	Martin Pollak	Physical Oceanographer	
	Evangeline Tollios	Senior Technician	
	T. J. Wehe	Hydrographic Technician	
	L. V. Worthington	Hydrographic Technician	
			854½
CURRENTS AND WAVES	Louise Allen	Laboratory Helper	
	Ruth Barker	Technician	
	Mortimer Datz	Technician	
	Richard Dimmock	Technician	
	Louise Dudley	Secretary-Technician	
	Thomas Duke	Research Assistant	
	Henry Hall	Technician	
	Mary Hunt	Statistical Technician	
	Arthur Klebba	Research Associate	
	H. R. Seiwell	Physical Oceanographer	
	Henry Stommel	Physical Oceanographer	
	W. S. von Arx	Physical Oceanographer	
	Dorothy Yarnold	Laboratory Helper	
	Edmond Watson	Research Associate	
			574½
PHOTOGRAPHY AND DRAFTING	Ann Hazelton	Ozalid Operator	
	David Owen	Photographer	
	G. G. Pasley	Draughtsman	
	Eva Shelnut	Draughtsman	
	John Stimpson	Draughtsman	
			166½

ASSIGNMENT	NAME	TITLE	TOTAL MAN DAYS*
MISCELLANEOUS SHOPWORK AND LABORATORY ASSISTANCE	Everett Berry Forrest Blake Warren Bowman Paul Dingwell Stanley Eldridge William Gallagher Fred Gaskell Betty Geggatt James Gifford Patrician Halderman Francois Hyde Marian Lane Anne Miner Eugene Mysona Stanley Poole Thomas Rennie Janet Renshaw Claude Ronne Dorothy Ryder Jane Souza Allard T. Spencer Lawrence Thayer Hallett Wagstaff Robert Walden Raymond Warren Nathaniel Wing		206
THEORETICAL STUDIES	J. G. Charney Bernard Haurwitz	Research Associate Research Associate	34½

* Man Day consists of 8 working hours.
** Time not included in figures for Man Days.

GRAND TOTAL 1885